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Tests of the Pumps and Wells of the University of Illinois

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TESTS

OF THE

PUMPS AND WELLS

OF THE

UNIVERSITY OF ILLINOIS

BY

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This is to certify that the following thesis prepared under the direction of Professor A. N. Talbot, Head of the Department of Theoretical and Applied Mechanics, by

NORVAL ENGER

entitled TESTS OF THE PUMPS AND WELLS OF THE UNIVERSITY OF ILLINOIS

is hereby approved by me as fulfilling this part of the requirements for the Degree of Bachelor of Science in Civil Engineering.

Ira O. Baker.

Head of Department of Civil Engineering

Tests of the University Pumps and Wells

The purpose of the tests was to determine the efficiency of some of the different pumping machinery used, and, to determine the effect of the rate of pumping on the well.

The water supply system of the University of Illinois consists of three 8-inch wells and one 12-inch well. Well No. 1 is served by an air lift, well No. 2, by a Downie double-acting steam head pump, and well No. 4, the 12 inch well is also served by a Luitweiler double-acting, continuous flow pump. The 8 inch wells have been in service from three to six years, while the 12 inch well was sunk last winter and has been in intermittent use for a few weeks only.

I. Tests of Luitweiler Pump and Well No. 4.

The 12-inch well is served by a belt driven Luitweiler pump, 15-inch stroke, $5\frac{3}{4}$-inch working barrel, designed to run at forty revolutions per minute. The pump was belt-connected to a $7\frac{1}{2}$ horsepower, 400 volt 2 phase constant speed induction motor.

During the tests the rate of discharge was measured by turning the water into a weighing tank, $1\frac{1}{2}$ minute at intervals of ten minutes. The revolutions per minute, the distance to the water in the well, and the power input of motor, were determined for each run.

Figure 1 shows the apparatus for determining the distance to the water in the well. Air was allowed to pass slowly into the $\frac{1}{4}''$ pipe until the gauge reading ceased to increase, then it was shut off and the gauge at A was read. This reading gave the pressure due to a column of water equal in height to the submergence of the air-pipe. Knowing the length of the airpipe the distance to the water in the well could be determined.

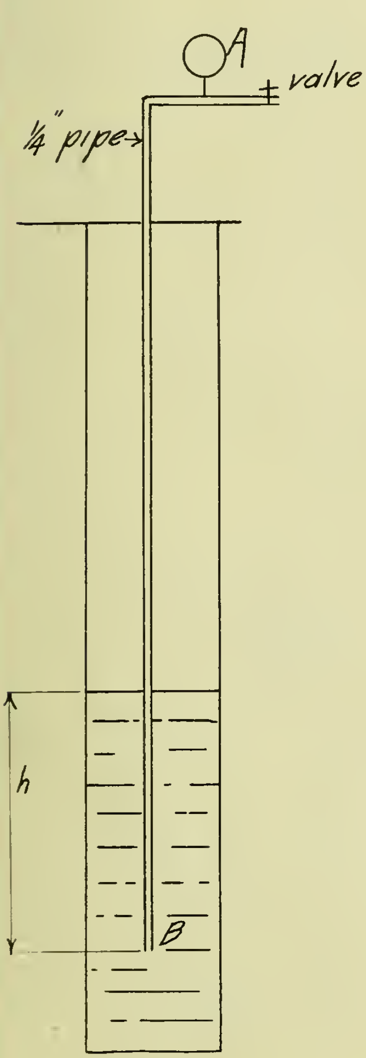


Fig. 1.

The revolutions of the pump were obtained by use of a revolution counter.

To determine the input to the motor a wattmeter was placed on the line to the motor and the mean

reading of the instrument during the time of the test was noted.

TABLE I.

TEST OF LUITWIELER PUMP AT WELL No.4.

Number.	Distance to Water in Well Feet	Total Head Feet	Actual Discharge Gal./Min.	Displacement. Gal./Min.	Power Input to Motor. H.P.	Useful Power Output. H.P.	Efficiency Pump and Motor Percent	Slip Percent	R.P.M.
1.	76.2	104.6	107.7	128.2	5.91	2.84	48.0	16.0	39.5
2.	76.1	104.5	108.5	132.2	5.86	2.86	48.8	18.5	40.4
3.	76.5	104.9	108.8	131.0	5.86	2.86	48.8	17.2	40.0
4.	76.7	105.2	107.8	130.5	5.86	2.84	48.5	17.7	39.9
5.	76.8	105.3	106.3	130.5	5.8.6	2.80	47.8	18.1	39.9
6.	76.8	105.3	106.4	131.2	58.7	2.80	47.7	18.6	40.1
7.	76.7	105.1	108.5	130.5	58.6	2.80	48.8	17.2	39.9
8.	76.8	105.2	107.2	131.2	58.5	2.83	48.4	18.7	40.1
9.	76.7	105.2	107.8	131.2	58.7	2.89	48.4	18.3	40.1
10.	76.8	105.2	109.8	133.0	58.6	2.88	49.2	18.1	40.6
11.	76.7	105.1	108.0	131.7	58.3	2.84	48.7	18.5	40.2
12.	76.7	105.1	109.2	133.2	58.5	2.88	49.1	18.7	40.7
13.	76.9	105.3	110.0	133.4	5.91	2.90	49.0	18.3	40.9
Av.	76.4	105.0	107.7	131.5	5.86	2.85	48.6	18.6	39.9

The first column gives the distance to the water-level in the well from the flange of the casing. It will be noticed that the water-level in the well lowered very little during the test, which covered over two hours. Previous to the test the pump had been run almost continuosly for several days so that a rapid lowering of the water in the well during the test could not be expected. The actions of the needle of the gauge seemed to contradict the manufacturer's claims of "pulseless flow". The pressure in the air pipe would vary by an amount equal to one or two inches of water. This variation was more marked when the lower plunger was rising. Perhaps the explanation is this: the strokes of the two plungers are the same, but the effective piston area is greater in the case of the lower plunger. The lower plunger rod is a 1 inch round iron, and the upper plunger rod is a $1\frac{1}{2}$ inch pipe, making about 3.6% difference in the effective plunger area. The pulsations could be detected by placing the hand on the discharge hose, and were distinct enough to give the strokes of the pump.

In order to determine the total head, a line of levels was run from well to pumping station, and the difference between the height of the discharge and the height of the flange at the well

determined. The length of the pipe was found and the number of bends counted. The loss of head due to friction and change of direction was then computed and amounted to 1.5 feet of water. To obtain the loss of head through the hose the wattmeter was read when the hose was attached and when removed. The difference in wattmeter readings was due to the loss of head in the hose. It was equal to 7.3 feet of water.

In order to determine the head under which the water was flowing into the well, the pump, after having run for about 48 hours, was stopped, and readings were taken of the rise of the water in the well at short intervals. For the first four minutes readings were taken every half minute but after that, every minute or two minutes as there was only a small change.

After allowing the pump to stop for about twenty minutes, it was started and readings were taken as before. The results are given on the next page intable No. III and are plotted in plate 1.

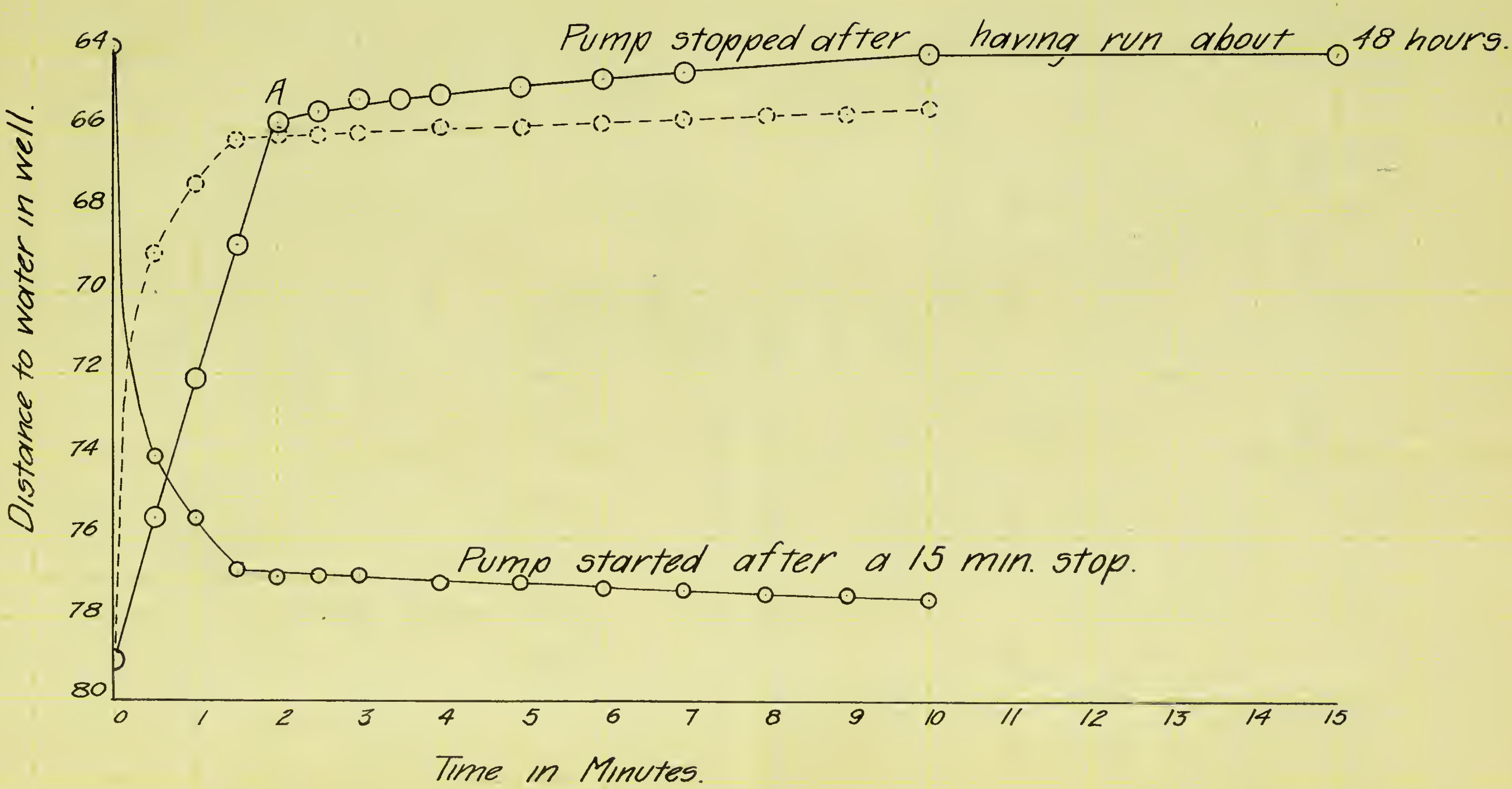
TABLE III.

RATE OF CHANGE IN WATER LEVEL IN WELL No. 4.

Time from Start Min. Sec	Distance from top of well to water. After stopping pump. Feet.	Rise	Distance from top of well to water. After starting pump. Feet.	Fall
0-0	79.0	0	63.9	0
0-30	75.5	3.5	74.0	10.1
1-00	72.1	6.9	75.5	11.6
1-30	68.8	10.2	76.8	12.9
2-00	65.8	13.2	76.9	13.0
2-30	65.5	13.5	76.9	13.0
3-00	65.2	13.8	76.9	13.0
3-30	65.2	13.8	—	—
4-00	65.1	13.9	77.1	13.2
5-00	64.9	14.1	77.1	13.2
6-00	64.7	14.3	77.2	13.3
7-00	64.5	14.5	77.3	13.4
8-00	—		77.4	13.5
9-00	—		77.4	13.5
10-00	64.1	14.9	77.5	13.6
12-00	—	—	—	—
15-00	64.1	14.9	—	—

PLATE I.

CURVES OF VARIATION IN HEIGHT OF WATER IN WELL—



The curves given on the preceding page are obtained from the data of table III. It will be noticed from the curve that when the pump was stopped the water rose at a nearly uniform rate for about two minutes, when the rate suddenly decreased and the rise continued at a constantly diminishing rate. The sketch below may aid the explanation of the sudden change of rate noted. This Figure illustrates the condition existing just before the pump was stopped, the water level inside the casing being at B, and the water level just outside the casing, at A. When the pump was stopped water level rose rapidly until the point A was reached, then it rose at the same rate as the surface of the ground water adjacent to the well. The rise would continue long enough for the surface of the ground water to become a plane.

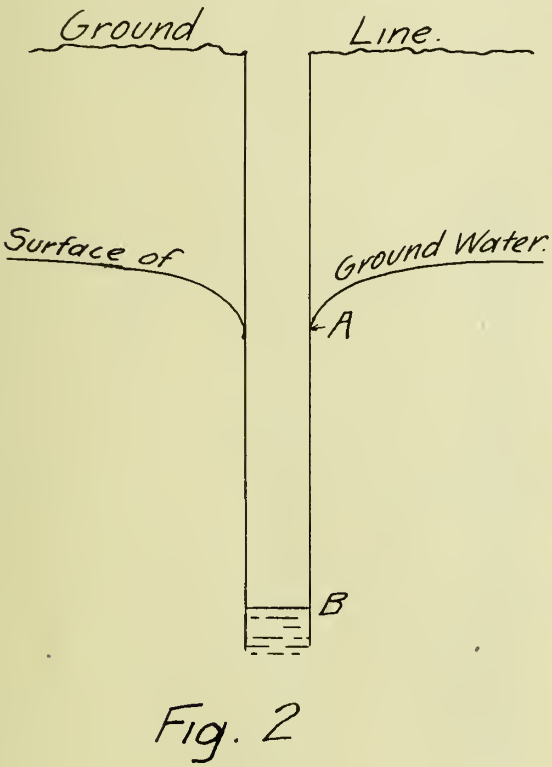


Fig. 2

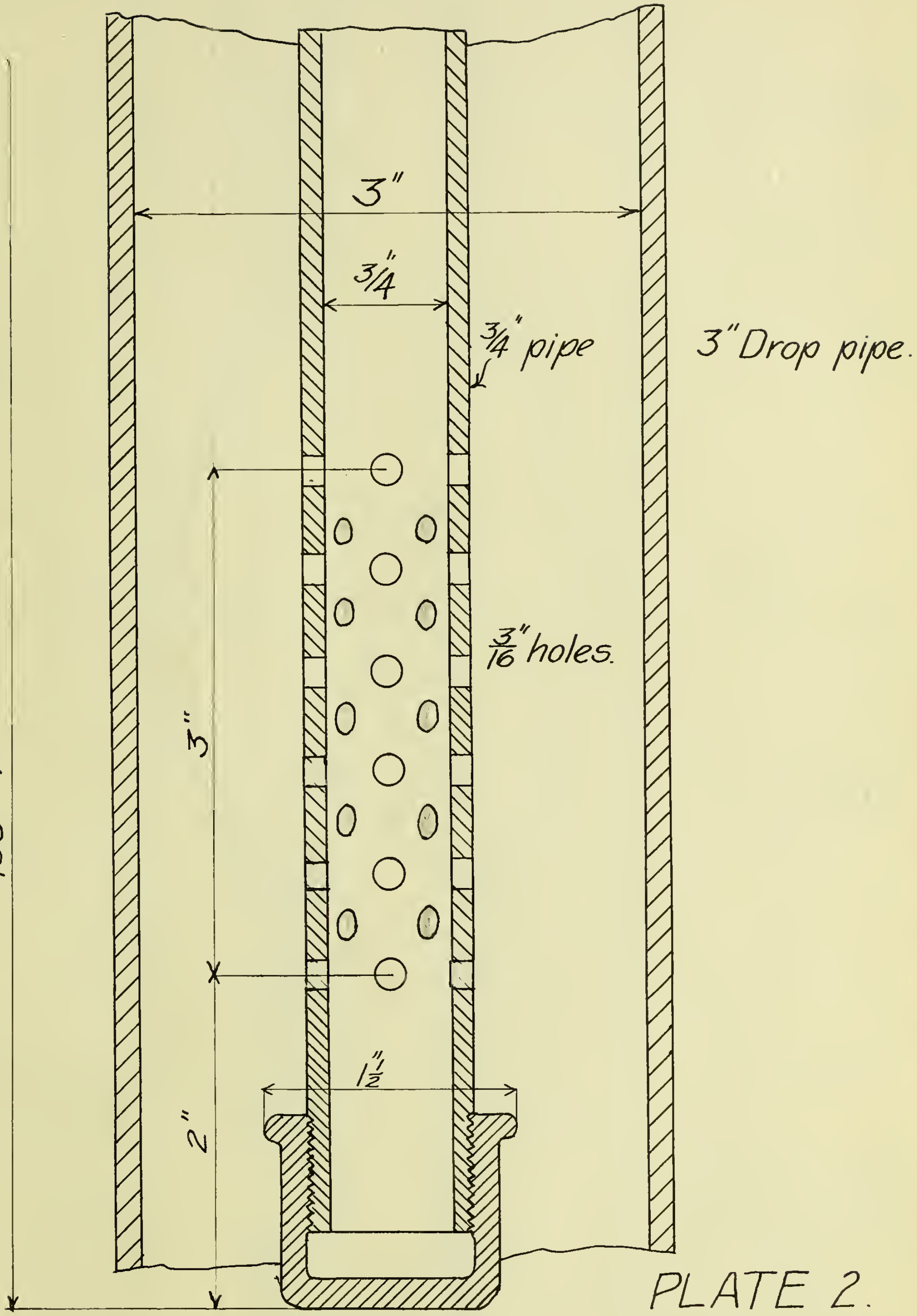
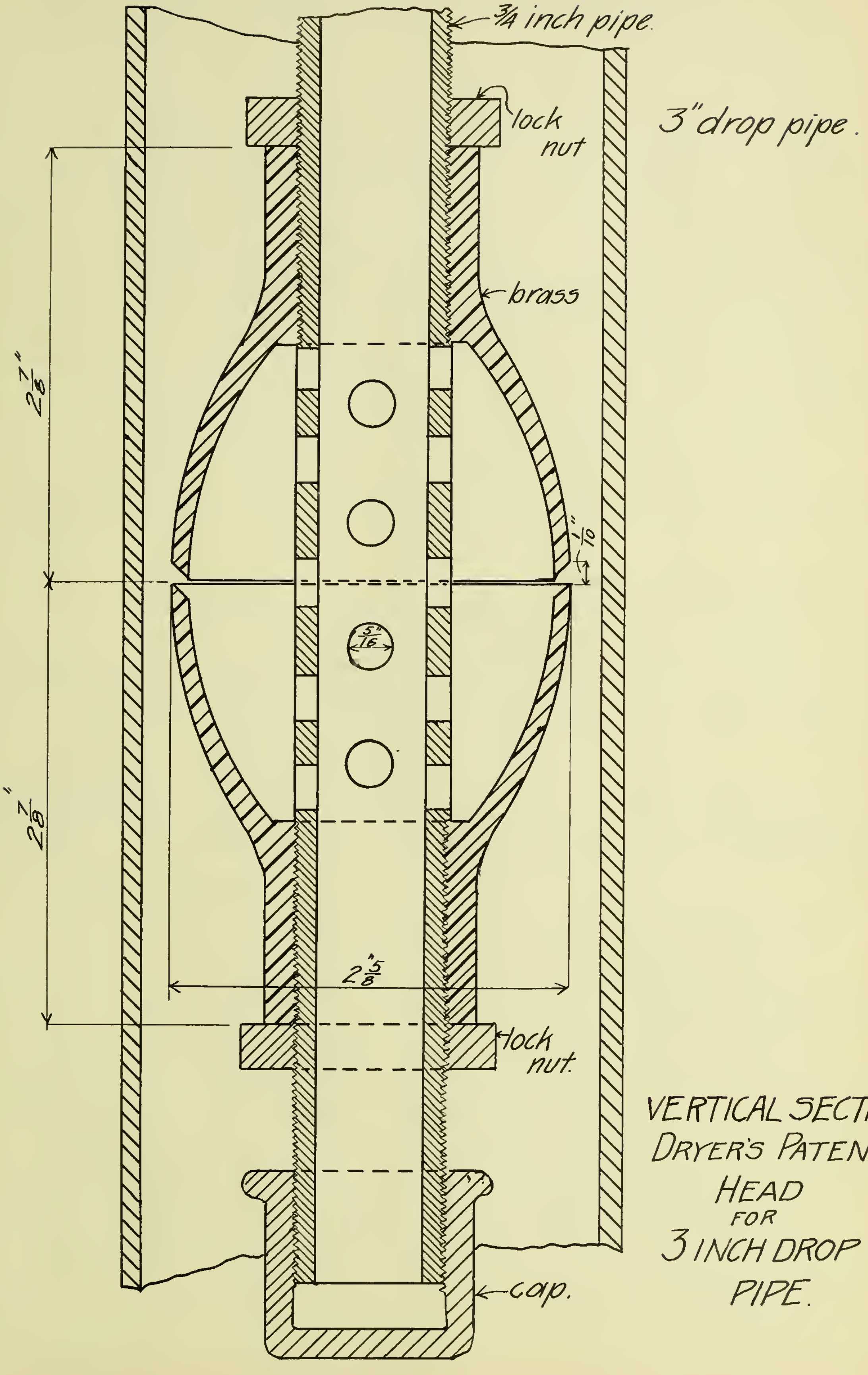


PLATE 2.
Airpipe Head
Perforated 3/4" pipe.

PLATE 3.



VERTICAL SECTION
DRYER'S PATENT
HEAD
FOR
3 INCH DROP
PIPE.

II. Tests of Air Lifts in Well No. 1.

Fine sand in wells may get in the plungers and cut the valve seats and leathers, or be otherwise troublesome. The air lift is one means by which water may be lifted from wells without having moving parts in the water. Tests were made in well No. 1 on two styles of head; (1) a 3/4 inch pipe with sides perforated, and, (2) Dryer's Patent head. Plate 2 shows the details of perforated pipe and Plate 3 shows a vertical section of Dryer's patent.

The entrance velocity into 3-inch pipe ~~is~~ was in both cases for the water pumped about 0.92 feet per second. The velocity of the water past the head is was in the case of the pipe 1.2 feet per sec and in the case of Dryer's patent the clearance is 3/16 of an inch and the velocity is 3.9 feet per second.

The holes in the perforated pipe have an area equal to 2.7 times that of the pipe and the area of the outlet of the patent head is was 1.3 times that of the pipe. Therefore there was no considerable resistance to the flow of air at the outlet. The bells of the head were set by the inventor in their most effective position.

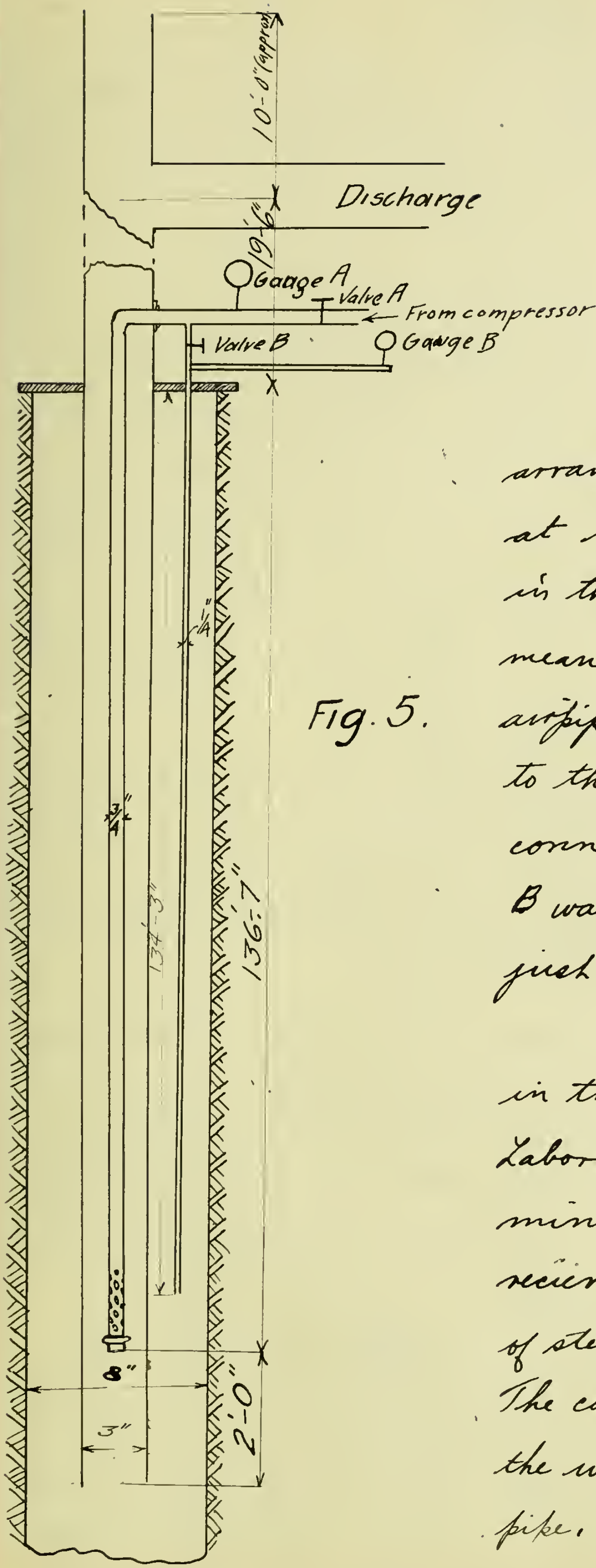


Fig. 5.

Figure 5 shows the arrangement of the pipes, gauges, etc., at the well. The different pressures in the air pipe were obtained by means of a valve at A. The small airpipe used to obtain the distance to the water in the well was connected to the larger one. Valve B was opened slightly and then closed just before a reading was taken.

The compressor is located in the Mechanical Engineering Laboratory. The revolutions per minute of the compressor, the reciever pressure and the weight of steam used per test were noted. The compressor was connected to the well by about 200 feet of 1 inch pipe. The air pressure on the

well, the air pressure on "distance to water" pipe, and the time required to discharge 1500 pounds of water were taken.

From these data the useful work was computed. (weight of discharge per minute x total head = foot pounds per minute). The energy delivered to the well was computed by the formula $pv(\log_e \frac{P}{p})$ = energy delivered, This assumes the expansion of the air to be isothermal, an assumption not greatly in error since the expansion takes place in water.

The submergence was only 33% so that the low efficiency obtained was to be expected. There is little difference in the efficiency of the two terminals under the conditions of the tests

It is unfortunate that such a large compressor had to be used as it was difficult to keep a uniform reciever pressure and, a miscount of one revolution per minute gave a 3% error in the amount of free air used.

Table III shows the results of the test of the air lift at Well No. 1. with the air pipe with perforated end. Table IV. shows the results of the test of the air lift a Well No. 1 with Dryer's patent head.

TABLE III.

Test of Air Lift in Well No. 1.

Number	Air Pressure at well. lbs/sq.in.	Discharge Gallons/Min.	Lift. Feet.	Submergence Percent.	Cu. ft. free Air per cu. ft. of water.	Efficiency Percent.	Steam per 100 gal. of water Pounds
1	30	20.2	103.6	33.2	35.6	8.75	31.6
2	33	22.2	104.2	33.0	35.0	7.5	37.3
3	33	21.8	104.2	33.0	35.2	7.7	34.0
4	36	22.9	105.3	32.2	33.7	7.4	34.9
5	36	22.9	105.3	32.2	33.7	7.4	38.2
6	40	23.5	106.0	31.5	32.7	7.3	38.2
7	40	23.8	106.0	31.5	32.3	7.3	48.0
8	40	23.9	106.0	31.5	32.2	7.4	40.0
9	42	24.0	106.0	31.5	32.1	7.2	41.7
10	42	23.9	106.0	31.5	34.1	6.7	43.6

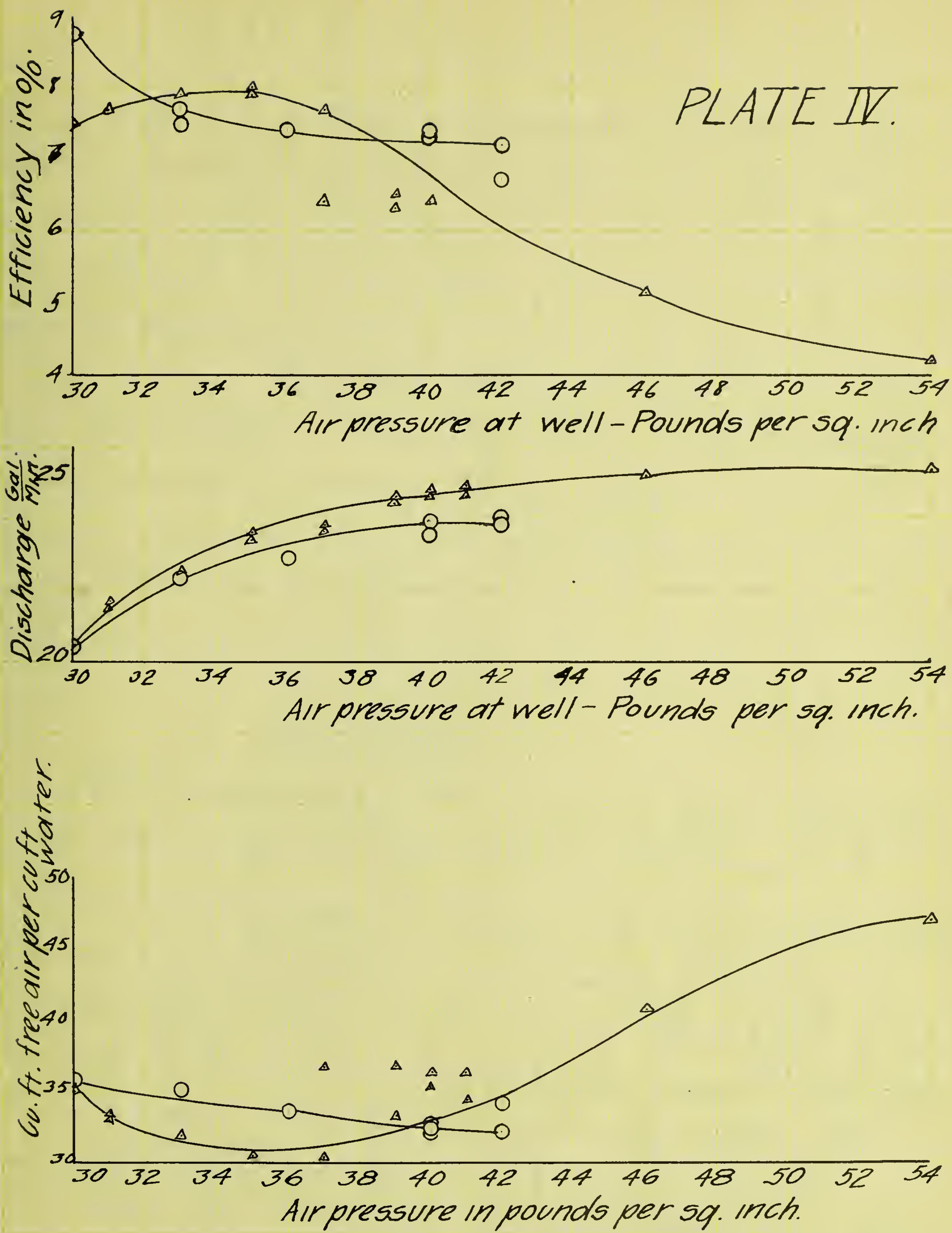
TABLE IV.

Test of Air Lift in Well No. 1.

Dryer's Patent Head.

No.	Air Pressure at well lbs./sq. inch	Discharge Gallons/Minute	Lift. Feet.	Submergence Percent	Cu. ft. free air per cu. ft. of Water.	Efficiency Percent.	Steam per 100 gal. of water Pounds
1	30	20.47	99.75	34.0	35.1	7.5	24.4
2	30	20.47	99.75	34.0	35.1	7.5	30.0
3	31	21.70	100.95	33.2	33.2	7.7	31.1
4	31	21.53	100.95	33.2	33.4	7.7	32.2
5	33	22.50	100.95	33.2	32.0	7.9	37.6
6	33	22.40	100.95	33.2	32.1	7.9	36.2
7	35	23.60	101.55	32.8	30.5	8.0	36.6
8	35	23.40	101.55	32.8	30.7	7.9	40.1
9	37	23.60	102.05	32.4	30.5	7.7	46.2
10	37	23.80	102.05	32.4	36.8	6.4	35.3
11	39	24.40	102.05	32.4	36.9	6.3	40.1
12	39	24.60	102.05	32.4	33.2	6.5	41.4
13	40	24.80	102.05	32.4	35.2	6.4	41.5
14	40	24.65	102.05	32.4	36.5	6.4	39.4
15	41	24.90	103.25	31.7	36.2	6.3	48.6
16	41	24.60	103.25	31.7	34.5	6.6	39.0
17	46	25.20	103.25	31.7	40.7	5.1	43.2
18	54	25.40	103.25	31.7	47.0	4.2	37.0

PLATE IV.



TEST OF AIR LIFT IN WELL No. 1.

○—○ Perforated Pipe Head.

△—△ Dryer's Patent Head.

The curves between pressure and efficiency show that the lower pressures were more efficient in raising water. The maximum rate of discharge was attained with the higher pressures and Dryer's Head gave the larger quantities at the same pressures.

With the perforated pipe head the air required per cubic foot of water raised decreased as the pressure increased. Using Dryer's Patent head the least amount of air per cubic foot of water was used when the air pressure was 35 lbs per square inch.

Conclusion.

The Luitweiler pump has a much higher efficiency than the air lift but the cost of installation at the well and cost of repairs is higher than the air lift. Where there is a compressor in use and it is desired to increase the yield of a well an air lift may be advantageously used. Such an installation may be desirable to save for a time the cost of a new well. The efficiency of the air lift in Well No. 1. could be increased by increasing the submergence. This could be accomplished by lowering the discharge, or by sinking the well below the screen and extending the drop. The probable maximum efficiency

under the new conditions would not warrant the expense of a new reservoir or of an increase in the depth of the well.